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Potassium Release
from exchangeable and nonexchangeable forms in
Ohio Soils

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POTASSIUM RELEASE FROM EXCHANGEABLE AND NONEXCHANGEABLE FORMS IN OHIO SOIL

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Exchangeable K (Potassium)[2] and K release measurements by chemical methods have been found to be highly accurate indexes to K absorption by plants and to response to K fertilization, under conditions, where there is control of the weight of soil from which plants absorb K and of the environmental conditions which influence K absorption by plants. Theoretically the exchangeable K at the beginning of a cropping period and the K release from nonexchangeable forms during the cropping period largely control the chemical availability of K to plants. These two factors, unless K is added as fertilizer, control the amounts of K chemically available in a given weight or volume of a soil.

The exchangeable K in soils is the fraction of soil K which has been found to be the most highly correlated with K absorption by crops over a short period of time. However, most soils in Ohio have sufficient amounts of exchangeable K to supply crops for only three years or less. If these soils are cropped without adding K the yields do not decrease to zero in three years. Potassium from nonexchangeable forms is being released to partially compensate for absorption by plants. Thus the K released from nonexchangeable forms during a cropping period of one crop or a rotation of crops is an important factor in the supply of K to plants. A chemical evaluation of both exchangeable K and K release from nonexchangeable forms can be used and should be used in assessing the K fertility status of soils. If an evaluation of the capacity of a

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[2]The symbol K will be used to designate the chemical element potassium hereinafter.

soil to supply K to a crop is desired for a short period the exchangeable K is probably the measurement to be made. However, if the evaluation is to be made for a long period of time the measurement of K release assumes relatively more importance and becomes of increasing importance as the length of time increases.

The objective of the study reported herein was to assess by chemical methods the K-supplying power of surface soils of various soils in Ohio.

MATERIALS AND METHODS

Soil samples were collected from the 0-6" and 6-12" layers from 235 locations in Ohio. Each sample came from an area of approximately 0.5 acres and was from an identified soil series. Approximately 1 pint of soil for each sample was air dried, ground to pass a 60 mesh screen, and was then stored for chemical analysis. The soil series and number of samples for each series are listed as part of Table 1.

The exchangeable K was extracted from soil using 1.0 **N** NH_4OAc at pH 7.0. A 10 g. sample of soil was leached with 100 ml. of NH_4OAc solution and the K extracted by this reagent was determined using a model 52-C Perkin-Elmer flame photometer.

A measure of K release from nonexchangeable forms was obtained by extracting the soil with boiling 1.0 **N** HNO_3. Various investigators (1-5) have found that the K release to this reagent is an accurate index to K release from nonexchangeable forms to plants during continuous cropping trials in the greenhouse. In this HNO_3 extraction, as previously used, a volume of HNO_3 was added to soil at a ratio of 10:1 and the mixture brought to a boil over a bunsen burner and allowed to boil gently for 10 minutes. The soil was then removed by filtration and after washing the soil with dilute HNO_3 the filtrate was analyzed for K. In the procedure used in this study the extraction was made by placing the soil-acid mixture in an oil bath for a given period of time. A 25-minute extraction, which included heating plus boiling time, with the oil at 113°C was found to extract the same amount of K as the previously used procedure. Figure 1 presents the relationship between K release and time of extraction for three soil samples. The 25-minute boiling period was satisfactory not only because it gave values that agreed with values of K release to a 10-minute boiling over a bunsen burner, but because shorter periods were more sensitive to small variations in time and because not much more K was released with additional time in the bath. A 2.50 g. sample of soil was placed in a 100 ml. beaker, 25 ml. of 1.0 **N** HNO_3 added, and the beaker placed in the oil bath. The beaker was then covered with a watch glass. After 25 minutes the beaker was removed from the bath. The soil was then filtered, washed with 0.1 N HNO_3 and K was determined in the combined leachate and washing.

The K release from nonexchangeable forms to this HNO_3 extraction was calculated by subtracting the exchangeable K value from the value for the total K in the HNO_3 extract. This difference is the K release from nonexchangeable forms but for brevity will be called K release.

RESULTS

In order to compare exchangeable K values among soil series the values of less than 75, 75 to 150, 150 to 225, 225 to 300, and greater than 300 lb. per acre furrow slice can be considered as very low, low, medium, high, and very high respectively. These categories should be used only as relative indications of the chemical availability of K and not as absolute values. A value of 150 lb. per acre does not mean that there is 150 lb. of K available to plants. If there is a very slow rate of K release the plants will not be able to absorb 150 lb. per acre because plants can not absorb all of the exchangeable K. That is, as the exchangeable K decreases it is less available to plants. On the other hand, if rates of release are high, the plants may absorb more than 150 lb. per acre.

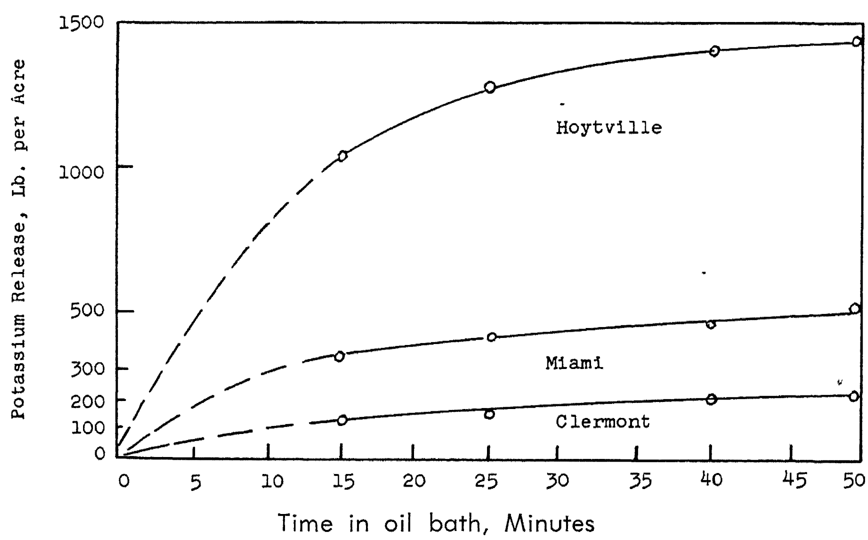

Fig. 1.—Relationship between K release to HNO_3 and the time in an oil bath at 113° C.

TABLE 1.—Exchangeable K and K Release to HNO_3 for Samples of the 0-6″ and 6-12″ Horizons of 46 Soil Series. Values in the Table are in Pounds per 2,000,000 Pounds of Air Dry Soil or Pounds per Acre Furrow Slice

Soil Series	Number of samples	Zero to Six Inch Depth				Six to Twelve Inch Depth			
		Exchangeable K		K Release		Exchangeable K		K Release	
		Average	Standard error	Average	Standard error*	Average	Standard error	Average	Standard error*
				Fine-texture Soils of the Lakebed					
Hoytville	4	272	14	1224	30	242	30	1114	22
Nappanee	4	181	14	704	78	212	12	696	163
Paulding	4	408	52	1584	144	346	32	1459	120
Toledo	4	304	19	1588	168	253	12	1376	112
Average		291		1275		263		1162	
				Sandy Soils of the Lakebed					
Berrien	4	114	28	192	12	74	34	150	12
Calumet	4	119	26	199	20	96	34	166	20
Maumee	4	56	13	184	52	32	7	166	54
Wauseon	4	90	48	300	138	42	16	232	84
Average		95		219		62		178	
				Soils Formed from High-lime Late Wisconsin Till					
Bellefontaine	4	380†	208	716	68	245†	64	696	56
Miami	9	212	26	648	48	188	15	706	56
Celina	12	186	17	644	28	164	12	696	38
Crosby	12	160	16	564	32	152	12	628	40
Brookston	12	250	12	874	80	220	11	868	66
Average		238		689		194		719	
				Alluvial Soils Associated with High-lime Late Wisconsin Till					
Fox	4	206	18	842	182	171	26	868	280
Genesee	8	168	13	714	64	132	8	670	58
Average		187		778		152		769	

Soil Series	Number of samples	Zero to Six Inch Depth				Six to Twelve Inch Depth			
		Exchangeable K		K Release		Exchangeable K		K Release	
		Average	Standard error	Average	Standard error*	Average	Standard error	Average	Standard error*
Soils Formed from High-lime Early Wisconsin Till									
Russell	4	242†	104	674	76	190†	46	664	46
Xenia	4	189	40	758	202	149	18	740	80
Fincastle	4	102	19	428	96	116	20	466	74
Average		178		620		152		623	
Soils Formed from Illinoian Till									
Rossmoyne	4	203†	112	270	40	90	20	152	54
Clermont	4	72	6	190	34	60	8	184	36
Average		138		230		75		168	
Soils Formed from Medium-lime Late Wisconsin Till									
Cardington	4	206	48	540	56	162	36	589	66
Bennington	4	230†	66	538	50	166	9	530	38
Marengo	4	300	58	850	102	252	22	850	88
Average		245		642		193		656	
Soils Formed from Low-lime Late Wisconsin Till									
Canfield	4	242†	76	414	50	150	48	424	38
Wooster	4	168	34	434	34	123	20	439	15
Rittman	4	114	17	441	42	96	9	541	56
Ravenna	4	156	16	418	40	140	20	431	38
Jefferson	4	138	22	376	36	104	7	400	54
Mahoning	6	156	24	426	38	142	26	465	40
Trumbull	6	140	24	438	48	131	24	476	34
Average		159		421		126		454	

Soil Series	Number of samples	Zero to Six Inch Depth				Six to Twelve Inch Depth			
		Exchangeable K		K Release		Exchangeable K		K Release	
		Average	Standard error	Average	Standard error*	Average	Standard error	Average	Standard error*
Alluvial Soils Associated with Low-lime Late Wisconsin Till									
Chagrin	6	117	0.2	523	48	73	5	490	54
Chenango	4	237†	108	434	44	134	54	407	26
Holston	4	145	24	460	120	86	4	450	96
Papakating	4	174	68	508	78	140	38	448	72
Average		168		481		108		449	
Soils Formed from Residual Materials									
Bratton	4	247	62	557	72	204	54	538	56
Fairmont	4	246	41	1504	418	177	12	1308	210
Hagerstown	4	126	18	400	48	112	20	411	50
Meigs	7	180	16	642	90	196	36	604	66
Muskingum	9	212	32	580	24	138	26	560	56
Upshur	2	291	0.6	927	236	255	5	1007	256
Wellston	4	246†	74	409	28	208	62	435	40
Westmoreland	7	316	58	1028	170	250	32	952	122
Zanesville	4	209	36	478	28	172	60	432	62
Average		230		725		190		694	
Alluvial Soil Associated with Residual Soils									
Huntington	8	162	12	887	74	138	12	838	98
Pope	4	142	14	515	56	90	3	510	62
Wheeling	4	184	30	757	88	112	24	616	112
Average		163		750		119		655	

*Standard error of the mean of the number of samples indicated.

†One sample in the series was unusually high.

For comparisons of various values of K release the values of less than 300, 300 to 500, 500 to 700, 700 to 900, and greater than 900 are very low, low, medium, high, and very high respectively. In greenhouse cropping of soils corn has not shown any response to K fertilizers on soils that have shown greater than 900 lb. K release per acre. Under continuous cropping in the greenhouse the drain on the K in the soil is much more intense than in the field where there is an intense drain only during the growing season. On the other extreme, with continuous cropping of soils with less than 300 lb. K release per acre, corn has been shown to give large increases in yield from K fertilization. Even with individual soils which had greater than 300 lb. exchangeable K per acre at the beginning of cropping there has been response to K fertilization when the K release was very low. Schmitz and Pratt (5) used a Trumbull and a Brookston soil which had 332 and 336 lb. exchangeable K per acre. Continuous cropping on the Trumbull soil gave K deficiencies in a short period of time whereas on the Brookston there were no deficiencies and no response to K fertilizer. The K release value for the Trumbull soil was 320 lb. per acre whereas for the Brookston soil it was 1284 lb. per acre.

Table 1 presents the exchangeable K and K release for the 235 locations that were sampled. The data are grouped into soil series and into various soil areas in the State. The standard error of each mean or average is presented so that some indication of the variations in each soil series is possible. The fiducial limits to the mean at the 0.05 probability level can be calculated approximately by multiplying the standard error by $\pm$ 2.5.

In the fine-textured soils of the lakebed the Hoytville, Paulding, and Toledo soils all showed high or very high in exchangeable K and all showed very high in K release. The need for K fertilization of crops grown in these soils under favorable conditions is extremely small. The K release values are sufficiently high that the exchangeable K absorbed each year by crops should be rapidly replenished by K release. Under conditions of very poor structure and restricted aeration there may be a need for K fertilization of these soils, but with adequate drainage and favorable structural conditions the native supplies of K should be sufficient for maximum yields of crops. Potassium fertilization of corn in 1952 and oats and alfalfa in 1953 on some of these soils yielded no increases in yield (unpublished data by J. L. Mortensen and W. P. Martin, and P. F. Pratt). The Nappanee soils were only medium to high in exchangeable K and K release. The soils of this series are more highly leached and more highly weathered than those of the other fine-textured soils in the same area and should be expected to have lower K levels.

The sandy soils of the lakebed in marked contrast to the fine-textured soils were all very low in K levels. In these soils particularly with shallow rooting annual crops the need for K fertilizers is high. With deep rooted perennials such as well established alfalfa the need for K fertilization may not be as great as for annual crops. One field of alfalfa on a sandy soil showed no response to K in 1953 (unpublished data by P. F. Pratt). The yields of alfalfa were high for three cuttings of hay and in spite of the fact that the alfalfa was 4 years old the stand was quite uniform indicating adequate nutrient element supplies were being supplied from the soil. The only fertilizer treatment had been manure at time of seeding. The exchangeable K and K release values for the surface 6 inches of this soil were 78 and 142 lb. per acre respectively.

The soils of the Miami catena were medium to high in exchangeable K and K release values. The dark-colored Brookston soils were the highest in this group and the gray Crosby soils were the lowest. The Bellefontaine, Miami, and Celina soils were intermediate.

The Bellefontaine series in this group of soils had one sample that showed unusually high exchangeable K in both the 0-6″ and 6-12″ horizons. Without this value the average was 172 and 182 lb. exchangeable K per acre in place of the 380 and 245 lb. values indicated in the table for 0-6″ and 6-12″ horizons respectively. The K release value for this unusual sample was not higher than the other three soils.

The two soil series formed from alluvial materials in the area of high-lime late Wisconsin till had nearly the same levels of K as the soils of the Miami catena on the till. The Fox soils tended to be a little higher in exchangeable K than the Genessee soils and the K release values were slightly higher than the Genessee.

The soils of the Russell catena developed on early Wisconsin high-lime till were slightly lower in K levels than the soils of the Miami catena. One of the samples of the Russell series showed unusually high exchangeable K values. Without this one value the average values for exchangeable K were 190 and 146 lb. per acre for the 0-6″ and 6-12″ horizons respectively.

The soils formed from medium-lime glacial till had approximately the same K levels as the soils of the high-lime till. The Marengo soils were comparable to the Brookston soils and the Cardington and Bennington soils were comparable to the Crosby soils.

The soils of the high-lime and medium-lime late and early Wisconsin till comprising the Miami, Russell, and Alexandria catenas, form a large area of soils of medium to high values in K release and low to high values in exchangeable K. In this area the need for K fertilization is not high. Certainly the K added as fertilizers should not be as great as the minimum amounts calculated to be removed by high yields of crops. These soils have reserves of K that can be and should be tapped and this is possible without serious limitations in yields.

The soils of the Rossmoyne and Clermont series of the Illinoian till in Southwestern Ohio were all very low in exchangeable K and K release. One of the samples of the Rossmoyne series showed 538 lb. exchangeable K per acre in the 0-6″ horizon whereas the other three samples showed less than 124 lb. per acre. The average for these three soils was 92 lb. per acre. Adequate yields of crops on these soils cannot be gotten without relatively high K fertilization. If any of the silt loam soils in Ohio should be fertilized with as much K as is removed in cropping these are the soils that should fit the requirements.

The soils formed from low-lime Wisconsin till were all uniformly low in K release. The exchangeable K values were also mostly in the low to medium range. These soils are not as deficient in K as the soils of the Illinoian till or the sandy soils of the lakebed area, but are not as high as the soils formed on medium-lime or high-lime Wisconsin till. The soils in this area are intermediate between the soils on Illinoian till and soils of the medium-lime and high-lime Wisconsin till in needs for K fertilizers. One soil in the Canfield series had an unusually high exchangeable K value in the 0-6″ horizon. The average value for the other three soils was 166 lb. per acre compared to 292 lb. per acre with this sample.

The alluvial soils associated with the low-lime Wisconsin till showed the same levels of K as the soils on the till itself.

The soils formed from residual materials ranged from low to very high in K release and exchangeable K. There were no samples that showed very low in either exchangeable K or K release. The Fairmont, Westmoreland, and Upshur soils gave very high values in K release, whereas the Wellston, Zanesville, Hagerstown, and Bratton series were low or medium in K release. The alluvial soils associated with the residual soils averaged about the same as the residual soils, with not as much variability among the different series.

Figure 2 presents the K release data for the 0-6" horizons for the soils formed from glacial till and lacustrine and residual materials, excluding the sandy soils in the lakebed area. The approximate locations of sample sites are given and the K release values are in terms of very low, low, medium, high, and very high.

The graphical presentation of the data in this figure agrees with the averages in Table 1. In the low-lime till of the northeastern section of Ohio the K release values were all medium to very low. In the lakebed area they were all medium to very high. In the Illinoian-till area

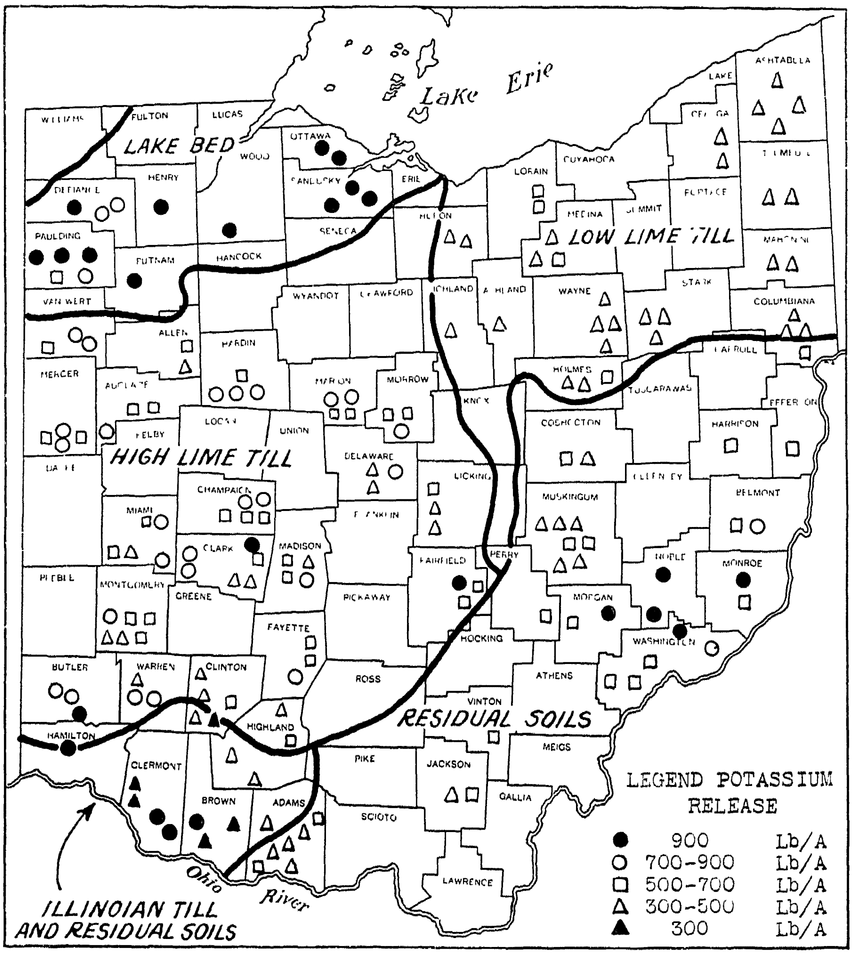

Fig. 2.—Approximate locations of sample sites and approximate K release values for the surface samples of soils developed from glacial till and lucustrine and residual materials.

they were all low to very low. In the large area of high-lime till they were very low to very high. In this high-lime till area the soils that were very high were mostly humic-glei soils. Those that were medium and high were mostly gray brown podzolic soils and those that were low to very low were mostly planosols or semi-planosols.

The data in this Figure suggest two areas of soils formed from residual materials where the K release was relatively high. One of these areas centers in Noble county. The samples from this area of Meigs, Upshur, and Westmoreland series. Samples of these same series that were taken from other areas are not as high in K release as those in this area. The other area is in Brown, Clermont, and Hamilton counties. The four soils from residual materials in these counties are all of the Fairmont series.

VARIABILITY WITHIN SOIL SERIES

There was a tendency for the K release value to be more a characteristic of the soil series than the exchangeable K value. The standard error of the mean expressed in percent averaged 19.2 and 16.7 percent for the 0-6″ and 6-12″ horizons respectively for the exchangeable K whereas the comparable values for K release were 13.0 and 13.1 percent. However, this tendency was not consistent with all series.

Table 2 presents data for five soils for which the exchangeable K values were extremely variable and yet the K release values were fairly constant. For the Bellefontaine soil the standard error was 55 and 26 percent for the 0-6″ and 6-12″ samples respectively whereas the comparable values for K release were 9.5 and 8.0 percent.

Since soil texture is one variable that influences rates of release of K the percent clay and percent sand in samples of ten soil series was measured. There was no significant relationship between texture and K release for nine of these, but with the Miami series there was a significant correlation. The correlation for variations in texture considerably reduced the variations in the K release values.

In cases where within a given series there is no relationship between K release and texture, the causative factors for variations in K release may be slight variations in K content of the parent material, variations in degree of weathering and variations in past management. If the variations in exchangeable K values within the soil series listed in Table 2 are a result of differences in past management, the K release values do not reflect the past management treatment to the same degree as the exchangeable K. Thus the most probable causes for variations in K release within a soil series are variations in K content of parent materials and in degree of weathering.

TABLE 2.—Exchangeable K and K Release for Samples at Four Locations for Each of Five Soil Series. Values Are in Pounds per 2,000,000 Pounds of Soil

Soil Series	Zero to Six Inches		Six to Twelve Inches	
	Exchangeable K	K Release	Exchangeable K	K Release
	Bellefontaine			
	1000	616	436	572
	140	904	178	846
	254	736	216	696
	124	616	150	670
Average	380	716	245	696
Standard error	208	68	64	56
	Canfield			
	168	340	82	378
	186	360	104	400
	144	396	122	382
	466	562	292	536
Average	242	414	150	424
Standard error	76	50	48	38
	Chenango			
	560	500	290	418
	116	422	130	432
	106	498	64	448
	116	316	50	330
Average	237	434	134	407
Standard error	108	44	54	26
	Russell			
	170	706	160	692
	158	734	148	724
	553	796	334	712
	90	462	128	528
Average	242	674	190	664
Standard error	104	76	46	46
	Wellston			
	466	386	144	354
	208	488	140	540
	138	358	144	396
	172	404	394	450
Average	246	409	208	435
Standard error	74	28	62	40

CORRELATIONS

Table 3 gives the linear correlation coefficients for some of the relationships involved in the data. The correlation between exchangeable K and K release was not high. For the surface horizon the correlation coefficient was 0.53. This value squared is 0.28, which means that the variations in exchangeable K or K release were only 28 percent associated with variations in the other. In only a few cases was the correlation between exchangeable K and K release sufficiently high that one might be a good index to the other and these cases are very specific for samples from small areas. Thus in this data the exchangeable K and K release values appear somewhat independent of each other.

The correlation between exchangeable K and K release was highest on the two extremes of low and high values of K release. With soils of intermediate values in K release the correlation was low and in the case of the soils of 600 to 800 lb. K release values it was not significant.

TABLE 3.—Linear Correlation Coefficients for the Indicated Relationships

Relationship	Correlation coefficient*
Exchangeable K vs K release	
All soils 0-6″	0.53‡
All soils 6-12″	0.62‡
Soils with 400 lbs. K release per acre 0-6″	0.58‡
Soils with 400 to 600 lbs. K release per acre 0-6″	0.37‡
Soils with 600 to 800 lbs. K release per acre 0-6″	0.13
Soils with 800 lbs. K release per acre 0-6″	0.64‡
Miami catena 0-6″	0.55‡
Residual soils 0-6″	0.58‡
Alluvial soils 0-6″	0.20
Fine-textured soils of the lakebed 0-6″	0.83‡
Sandy soils of the lakebed 0-6″	0.54†
Soils of the Illinoian till	0.83†
Exchangeable K 0-6″ vs 6-12″	0.77‡
K release 0-6″ vs 6-12″	0.95‡
Exchangeable K vs K release for 8 groups of 15 soils taken at random, 0-6″	
Group 1	0.57†
2	0.94‡
3	0.82‡
4	0.55†
5	0.30
6	0.61†
7	0.73‡
8	0.69‡

*The square of this coefficient gives the degree of association of the two variables.
†Significant at 5 percent level of probability.
‡Significant at 1 percent level of probability.

The correlation between exchangeable K and K release is an important factor to be considered when a group of soils are brought into the greenhouse for a study of K release during cropping. The correlation coefficients given for the groups of 15 soils selected at random indicate that the correlation between these two factors will vary from very low to very high depending on the individual soils selected for the study. Values, reported in the literature, for the coefficient of correlation between exchangeable K and K release for groups of soils used in greenhouse studies were 0.18, 0.63, and 0.78 (1, 4, 5). These variations are approximately the same order of magnitude as those reported in Table 3.

The relationship between the average exchangeable K values for each series and the average K release is presented in Figure 3. Even when some variations are removed by using averages the correlation is not sufficiently high that the K release value can be accurately predicted from the exchangeable K. Six of the soil series studied had exchangeable K averages that were within the limits of 170 + 10 lbs. per acre yet the K release values for the soils varied from 434 to 887 lbs. per acre.

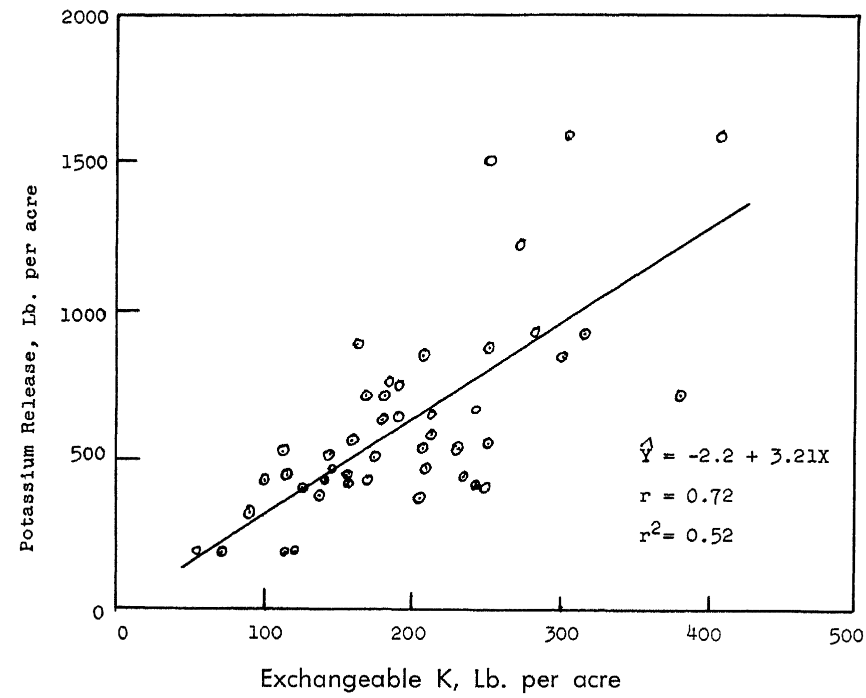

Fig. 3.—Relationship between exchangeable K and K release for the average values for the 0-6" horizons of 46 soil series.

The correlation between exchangeable K in the 0-6″ and in the 6-12″ horizons was 0.77. This value squared is 0.59. Thus a measurement of the exchangeable K in the surface plow layer accounted for only 59 percent of the variations of exchangeable K in the immediate subsurface below the plow layer.

The K release values in the two horizons were highly correlated. The coefficient 0.95 squared is 0.90 which indicates a high degree of accuracy in prediction of K release for the 6-12″ horizons from those of the 0-6″ horizons. The fact that the K release values for the two horizons were more highly correlated than the exchangeable K values is another indication that the K release value is more a characteristic of the soil series than the exchangeable K.

POTASSIUM CONTENT OF SIZE FRACTIONS

The total K content of various size fractions of surface soils has been used as an indication of relative degree of weathering of soils. Also, it has been demonstrated that the percentages of the total K content of silts that are soluble in HNO_3 might be more related to degree of weathering than the total content of K itself (2).

In order to study the K characteristics as related to relative degrees of weathering 14 soil samples were fractionated into less than 2, 2 to 10, 10 to 20 and 20 to 50 micron fractions. The organic matter was destroyed by treatment with H_2O_2 and the various size fractions of the mineral matter were separated by sedimentation. The 20 to 50 micron fraction was separated from the sand by the use of a 325 mesh sieve.

Exchangeable K was determined for the clay and finest silt fraction only. The K release to HNO_3 was determined for all four fractions and total K was determined for the 2 to 10 and 10 to 20 micron fraction. Total K was determined by a flame photometric analysis of the dissolved ash following a HF-HCl-H_2SO_4 digestion of the sample.

Table 4 presents the data for the K release, the total K, and the percentage solubility of K in the silt fractions of 14 soils. The soils are listed in a relative degree of weathering sequence with the least weathered at the top. This is the sequnce suggested by the K data and not by a consideration of morphology or other chemical properties. A weathering sequence based on morphology, depth of acid layer, and degree of acidity would be nearly the same as the one in the table with a few exceptions. The Russell soils have in the past been considered to be more highly weathered than the Miami soils and the Miami and Russell more highly weathered than the Marengo and Brookston soils.

TABLE 4.—Potassium Release, Total K, and Percent Solubility of Total K in HNO_3 for the Indicated Size Fractions of 14 Soil Samples

Soil Series	Potassium Release*				Total K*		Percent Solubility†	
	2u	2 to 10u	10 to 20u	20 to 50u	2 to 10u	10 to 20u	2 to10u	10 to 20u
Hoytville	1242	223	118	77	22,750	17,125	0.98	0.69
Russell	944	198	117	80	22,000	16,875	0.90	0.69
Toledo	1092	187	114	69	23,125	17,325	0.81	0.66
Miami	944	177	106	68	19,500	15,125	0.91	0.70
Marengo	846	152	95	66	19,250	14,500	0 79	0.66
Brookston	778	151	94	60	21,250	15,625	0.71	0.60
Wooster	580	154	96	66	20,250	14,500	0 76	0.66
Crosby	588	145	97	60	18,250	14,625	0 79	0.66
Wellston	432	142	87	60	21,125	15,000	0 67	0.58
Bennington	535	127	84	58	16,125	11,750	0.79	0 71
Fincastle	540	117	79	44	18,000	15,125	0.65	0.52
Rossmoyne	408	122	70	46	16,500	13,250	0.74	0.52
Trumbull	542	122	66	40	17,500	11,625	0.70	0.57
Clermont	569	98	33	24	13,125	11,125	0.75	0.48

*Units in ppm. multiply by 2 to get lb. per 2,000,000 lb.
†The K release values as a percentage of the total K.

The percentage solubility of total K in the silt fractions of these soils was small and there was relatively small variability among soils. In a similar study of Iowa soils (2) the solubility of K in HNO_3 in the 10 to 20 micron fraction varied from 0.70 to 3.0 percent, whereas comparable figures from table 4 are 0.48 to 0.71 percent. This difference would suggest that all of the soils listed in Table 4 are more highly weathered than the soils of Iowa for which similar data are available, or that the K-bearing minerals in the two areas are different.

DISCUSSION

In the work reported here the exchangeable K in the 0-6″ horizon was only 28 percent associated with K release from nonexchangeable forms in the same horizon and only 54 percent associated with exchangeable K in the 6-12″ horizon. If the K release from nonexchangeable forms in both the 0-6″ horizon and the 6-12″ horizon and the exchangeable K in the 6-12″ horizon are important factors in supplying K to plants, the exchangeable K in the surface layer is not a satisfactory test for the K-supplying power of the surface foot of soil.

There is thus a need for fertility work in which the response to K fertilizers is correlated with exchangeable K and K release for the various horizons of the soil which are penetrated by the root systems of crop plants. Work of this nature would permit the formulation of sampling techniques which would give representative samples of the soil volumes from which various crops absorb K in various types of soil profiles.

In the area of the Miami, Alexandria, and Russell catenas the K release values were related to the position of the soil in the drainage pattern. The dark-colored humic glei soils were the highest in K release. The gray brown podzolic soils were intermediate and the planosols were lowest. In the soils of the low-lime till in northeastern Ohio this difference in soils within the same catena was absent. Within this area the gray brown podzolic soils and planosols had the same K release values. The difference in the nature of the parent materials in these two distinctly different areas is probably the key to the explanation of the different behavior of K in these areas.

More work of the type reported here is needed. More samples of each series should be collected and a greater number of profile horizons should be sampled. However, along with a project of this nature there is a need for information relating the exchangeable K and K release in profile horizons to the absorption of K by plants. A combination of this type of chemical and fertility data would permit a relatively accurate mapping of K resources in the soils of Ohio.

The K release values for the soils analyzed in this work were more a characteristic of the soil series than the exchangeable K values. This conclusion is supported by evidence obtained by measuring K release values before and after long continuous cropping in the greenhouse. The soils used by Schmitz and Pratt (5) gave the same K release values after cropping as before cropping. However, during the same cropping period the exchangeable K decreased significantly.

SUMMARY AND CONCLUSIONS

Several samples of the 0-6″ and 6-12″ horizons of each of 46 important series of soils of Ohio were analyzed for exchangeable K and K release to 1.0 N HNO_3. Several samples were fractionated into four size fractions and these fractions analyzed for K release to HNO_3. Two fractions were analyzed for total K.

The K release value was more a characteristic of the soil type and the soil area than the exchangeable K values.

The correlation between exchangeable K and K release was not high. Exchangeable K in the 0-6″ horizon is not highly correlated with exchangeable K in the 6-12″ horizon.

The K release in the 0-6″ horizon is highly correlated with the K release in the 6-12″ horizon.